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(54) TREATMENT MACHINE WITH A FLAT PANEL IMAGER

BEHANDLUNGSAPPARAT MIT FLACHBILDSCHIRM

APPAREIL DE TRAITEMENT A DISPOSITIF D'IMAGERIE PLAT

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(73) Proprietor: **Varian Medical Systems, Inc.**
Palo Alto, CA 94304 (US)

(72) Inventors:

- **SHAPIRO, Edward, G.**
Menlo Park, CA 94025 (US)
- **SEPPI, Edward, J.**
Portola Valley, CA 94028 (US)
- **PAVKOVICH, John, M.**
Palo Alto, CA 94304 (US)

- **JOHNSEN, Stanley, W.**
Palo Alto, CA 94306 (US)
- **COLBETH, Richard, E.**
Palo Alto, CA 94024 (US)

(74) Representative: **Lees, Gregory Alexander et al**
Dehns
St Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

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Description

TECHNICAL FIELD

[0001] The present invention pertains in general to therapeutic radiology. In particular, the invention involves imaging devices.

BACKGROUND

[0002] An objective of radiation therapy is to maximize the amount of radiation to a target volume (e.g., a cancerous tumor) and minimize the amount of radiation to healthy tissues and critical structures. The process of identifying the precise location of the target volume immediately prior to a dose of therapeutic radiation is key to the objective. Since each patient is treated over 30 to 40 fractionated sessions, then the time allowed for each session is relatively short, e.g. 10 to 15 minutes, so the process must be fast as well as accurate.

[0003] In the case of electronic portal imaging, megavolt therapeutic X-rays emerging from the patient can be used to generate images. However, this method of target location generates images of low contrast and quality, in addition to incidentally damaging healthy tissue. As a result, imaging with megavoltage (MV) radiation is used primarily for portal verification, that is, to confirm that the treatment volume is being radiated.

[0004] Radiotherapy simulator machines have been used to perform the pre-treatment analysis of the target volume before a radiotherapy treatment machine applies the therapeutic radiation. However, traditional radiotherapy simulator machines use bulky image intensifier tube detectors to capture images of the treatment volume. These image intensifier tube detectors have the disadvantage of being very large relative to their imaging area. They also have image spatial distortions from their spherical shaped input surface and the orientation of the intensifier tube with the Earth's magnetic field.

[0005] WO 01/60236 discloses a radiation therapy system that includes a radiation source that moves about a path and directs a beam of radiation towards an object and a cone-beam computer tomography system. The cone-beam computer tomography system includes an x-ray source that emits an x-ray beam in a cone-beam form towards an object to be imaged and an amorphous silicon flat-panel imager receiving x-rays after they pass through the object, the imager providing an image of the object. A computer is connected to the radiation source and the cone beam computerized tomography system, wherein the computer receives the image of the object and based on the image sends a signal to the radiation source that controls the path of the radiation source; a radiation therapy system that includes a radiation source that moves about a path and directs a beam of radiation towards an object and a cone-beam computer tomography system. The cone-beam computer tomography system includes an x-ray source that emits an x-ray beam in a cone-beam

form towards an object to be imaged and an amorphous silicon flat-panel imager receiving x-rays after they pass through the object, the imager providing an image of the object. A computer is connected to the radiation source and the cone beam computerized tomography system, wherein the computer receives the image of the object and based on the image sends a signal to the radiation source that controls the path of the radiation source.

10 SUMMARY OF AN EMBODIMENT OF THE INVENTION

[0006] Viewed from a first aspect, the present invention provides an apparatus, comprising: a rotatable gantry; a translatable treatment couch coupled to the rotatable gantry via a communications network; means for receiving a treatment plan to instruct the apparatus to at least adjust a therapeutic megavoltage radiation source into position to align a treatment volume with the therapeutic megavoltage radiation source; first means for applying a first cone-beam radiation beam coupled to the rotatable gantry, wherein the first means for applying includes a kilovoltage radiation source; second means for applying a second cone-beam radiation beam coupled to the rotatable gantry using the treatment plan, wherein the second means for applying includes the therapeutic megavoltage radiation source; first means for capturing first image projection data applied by the kilovoltage radiation source with a first flat-panel kilovoltage radiation imager, which is coupled to the rotatable gantry; second means for capturing second image projection data applied by the megavoltage radiation source with a different, second flat-panel megavoltage radiation imager, which is coupled to the rotatable gantry; means for storing the captured image projection data coupled to the rotatable gantry via a communications network; means for generating cone-beam computed tomography (CT) volumetric image data from the captured image projection data captured by the first flat-panel imager; and a computer for controlling the couch and thereby placing a patient on the couch in an operative position to begin a treatment based on a comparison of the second image projection data with at least one reference image of the treatment plan.

[0007] Viewed from a second aspect, the present invention provides a machine-readable medium having instructions to cause a clinical treatment machine to perform a method to perform a clinical treatment, the method comprising: receiving a treatment plan to instruct the apparatus to at least adjust a therapeutic megavoltage radiation source into position to align a treatment volume with the therapeutic megavoltage radiation source, the megavoltage radiation source being coupled to a rotatable gantry; instructing the clinical treatment machine to capture first image projection data from a first flat-panel kilovoltage imager coupled to the rotatable gantry, the first image projection data being for generating cone-beam computed tomography (CT) volumetric image data, wherein the first image projection data is from a cone-

beam kilovoltage radiation beam source coupled to the rotatable gantry; instructing the clinical treatment machine to apply a megavoltage cone-beam radiation beam from the therapeutic megavoltage radiation source using the treatment plan; instructing the clinical treatment machine to capture second image projection data from a second flat-panel megavoltage imager coupled to the rotatable gantry, storing the first and second captured image projection data; and controlling a translatable treatment couch to place a patient on the couch in an operative position to begin a treatment based on a comparison of the second image projection data with a least one reference image from the treatment plan, wherein the translatable treatment couch is coupled to the rotatable gantry via a communications network.

[0008] Viewed from a third aspect, the present invention provides a computer program product for controlling a translatable treatment couch and placing a patient, on the couch, in an operative position to begin a treatment using the apparatus of the first aspect, the computer program being adapted to: control the means for capturing image projection data in order to capture first image projection data from a first flat-panel kilovoltage imager and to capture second image projection data from a second flat-panel megavoltage imager, both of which imagers are coupled to the rotatable gantry, the first image projection data being for generating cone-beam computed tomography (CT) volumetric image data, wherein the first image projection data is from a cone-beam kilovoltage radiation beam source coupled to the rotatable gantry, and wherein the second image projection data is from a cone-beam megavoltage radiation beam source coupled to the rotatable gantry; store the captured first and second image projection data; and control a translatable treatment couch to place a patient on the couch in an operative position to begin a treatment based on a comparison of the second image projection data with a least one reference image from the treatment plan, wherein the translatable treatment couch is coupled to the rotatable gantry via a communications network.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements and in which:

Figure 1 is an illustration of a side view of a simulation treatment machine;

Figure 2 is an illustration of a process flow of a method for generating a treatment plan;

Figure 3 is a side view of one embodiment of a clinical treatment machine; and

Figure 4 illustrates a process flow of one embodiment of a method for implementing a treatment plan.

DETAILED DESCRIPTION

[0010] In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be evident, however, to one skilled in the art that the present invention may be practiced without these specific details. In some instances, well-known structures and devices are shown in gross form rather than in detail in order to avoid obscuring the present invention. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that logical, mechanical, electrical, and other changes may be made without departing from the scope of the present invention.

[0011] A clinical therapy simulation machine having a cone-beam computed tomography (CT) radiation source and a flat-panel imager is described. The clinical therapy simulation machine is capable of manipulating the flat-panel imager and the cone beam CT radiation source to generate x-ray images for determining patient setup/alignment and a clinical treatment plan to be implemented by a clinical treatment machine.

[0012] Figure 1 is a side view of one embodiment of a simulation treatment machine 100. The simulation treatment machine 100 includes a rotatable gantry 202 pivotally attached to a drive stand 203. A cone-beam CT radiation source 204 and a flat panel imager 206 oppose each other and are coupled to the rotatable gantry 202. The cone-beam CT radiation source may be a kilovoltage radiation source generally in the 50 to 150 kilovolt (kV) energy range, and for example at 125 kilovolts peak (kVp).

[0013] A treatment couch 218 is positioned adjacent to the gantry 202 to place the patient and the target volume within the range of operation for the radiation source 204 and the imager 206. The couch 218 may be connected to the therapy simulator rotatable gantry via a communications network and is capable of translating in multiple planes plus angulation for positioning and repositioning the patient 205 and therefore the target volume.

[0014] The gantry 202 can rotate 214 about an isocenterline 215 to place the radiation source 204 and imager 206 at any position 360 degrees around the target volume, for example, to generate CT scan image data. As will be described, cone-beam CT image data can be used to generate a three-dimensional representation of the patient anatomy and the target volume. The image data may further be used to generate a treatment plan to tailor a dose of therapeutic radiation to the target volume.

[0015] Figure 2 is a process diagram of a method for generating a treatment plan. At block 310, a patient is placed on the treatment couch 218 and the couch 218 positioned relative to the simulation machine 100. At block 320, the gantry 202 rotates around the patient 205 while the radiation from the cone-beam CT radiation

source 204 impinges the flat-panel imager 206. The gantry 202 rotates and collects image data until a computer can calculate a representation of the patient and the target volume. For example, software in a computer may take the image data to generate cone-beam CT volumetric image data for generation of a treatment plan. At block 330, a treatment plan may be generated from the collected image data. The treatment plan may then be transferred, at block 340, to a clinical treatment machine to provide instructions to the clinical treatment machine, for example, to position a therapeutic radiation source to apply a radiation dose to a target volume, and to minimize dose to health tissue and critical structures.

[0016] The flat panel imager 206 may be a real-time digital x-ray imager incorporating a large-area amorphous silicon sensor array with a high-sensitivity cesium iodide (CsI) scintillator. The flat panel imager may include a receptor module that incorporates the amorphous silicon sensor array, which accepts incoming X-ray photons and converts them to a digital video signal. The X-ray to light conversion may be provided by a thin or thick columnar CsI:TI (cesium iodide: thalium doped) scintillator. The scintillator may be vacuum deposited in a thin (e.g. 0.6 mm) layer or include individual CsI crystals (e.g., being approximately 9 mm thick with an approximate 0.38 mm x 0.38 mm pixel pitch) supported in a housing with an aluminum window (e.g., approximately 1 mm thick). The top of the thin CsI scintillator may be coated with a reflective powder/epoxy mixture. Five sides of each thick crystal may be coated with a reflecting powder/epoxy mixture. The sixth side may be in contact with and face the flat-panel sensor. Alternatively, the scintillator components may have other dimensions.

[0017] The receptor module may also include a power supply module (e.g., 24 VDC power), interconnecting cables (e.g., fiber optic control and data cables), and drive and readout circuits followed by digital data conversion and transmission capabilities well known to those of ordinary skill in the art.

[0018] It should be appreciated that the flat panel imager may be a two-dimensional large flat panel imager that can operate, for example, at 15 to 30 frames per second (fps) over a wide range of dose. In this way, fluoroscopic, radiographic and cone-beam CT imaging can all be achieved with the same flat panel system. Typically, 300-900 projections may be collected during a single rotation of the gantry depending on the image resolution and dose requirements. Fewer projections allow for a faster collection of cone-beam CT image data (e.g., in 20 to 40 seconds depending on gantry speed limits), thereby, allowing for lower dose cone-beam CT images with less patient motion artifacts. Alternatively, the imagers may operate at other frame rates.

[0019] The flat panel imager may have a landscape orientation, an active area of 39.7x29.8cm² with 194 micron pixel pitch, and a pixel count of 2048x1536 pixels. It can operate at a frame rate of 7.5 fps in full resolution mode and at a frame rate of 30 fps in 2x2 binned mode

- where the pixel count is reduced to 1024x768 pixels². For example, the flat panel imager may be an amorphous silicon (a-Si) imager available from Varian Medical Systems of Palo Alto, California, under the tradename PaxScan™ 4030A. The PaxScan™ 4030A detectors are each 40 cm x 30 cm. The detectors may be coupled to signal processing circuitry comprising a preamplifier stage with dynamically controllable signal gain, as described in US patent number 6,486,808, to improve contrast resolution and dynamic range.

[0020] The readout electronics may also be located out of the path of the primary cone-beam CT radiation source 404. The flat panel imager 206 may also employ a split data-line where the top half of the array and the bottom half of the array are read out simultaneously. This allows the imager 206 to read out more rapidly and reduces the parasitic capacitance of the data-lines, which in turn reduces the noise gain of the readout charge amplifiers. It should be appreciated that only half of the frame time is used to read out the pixels. During the rest of the frame time, the sensor can be irradiated without generating any interference patterns due to the pulsing of the cone-beam CT radiation source 204. In addition, it should also be appreciated the control system of the flat panel imager 206 allows an external synchronization signal (from the computer 220) to initiate the readout of a frame. This allows the user to externally control when the imager will acquire an image.

[0021] A command processor module 225 may manage the receptor module, processes the digital video, and provides interfaces to other components of the simulator 100. The command processor module 225 may include a microcontroller-based, single board computer running a real-time operating system with acquisition, control, and interface software. Also, included in the command processor may be a high-speed digital video interface card, a dedicated image processor card to perform real-time image corrections, a system interface card, and a parallel output to transmit image data to an external image processor and display. Scan-converted digital and analog video may also be provided.

[0022] The captured cone-beam CT image projection data may be delivered and stored to a computer 220. As shown in Figure 1, the computer 220 connects to the simulator 100 and the command processor 225 via communications network 240. The computer 220 may control the synchronized movement of the simulator 100 including the rotatable gantry 202, the cone-beam CT radiation source 204, imager 206, and the treatment couch 218. Specifically, the computer 220 may be used by an oncologist to display image projection data on a monitor 222, control the intensity of the cone-beam CT radiation source 204, and control the gantry angle.

[0023] The cone-beam CT image projection data may also be transferred to a cone-beam CT reconstruction computer 221 that includes software designed to achieve rapid cone-beam CT image generation. The computer 221 can merge or reconstruct the image data into a three-

dimensional representation of the patient and target volume. In one embodiment, cone-beam CT reconstruction software may allow for full-cone and partial-cone input data that can produce cone-beam CT images (e.g., approximately 26 to 48 cm diameter) at a specific source-to-imager distance (e.g., 140 -150 cm). In addition, in this way, the clinical simulator machine 100 and cone-beam reconstruction software may also allow for large diameter (e.g., approximately 48 cm) axial image volumes.

[0024] In one embodiment, the cone-beam CT reconstruction software may transform the image projection data into volumetric CT image data. The volumetric CT image data may include full-fan and/or partial cone image data to reconstruct head size (e.g. 26 cm diameter x 17 cm length) and body size (e.g. 48 cm diameter x 15 cm length) volumes. For example, the partial-cone method may be used to obtain body size scans when the flat panel imager is not long enough to image the full body in each projection. If the 15 or 17 cm axial section is not wide enough and therefore does not cover sufficient anatomical volume, then multiple scans can be performed. For example, in the two scan case, the patient may be moved axially by 15 or 17 cm couch movements between scans and the reconstructed image volumes may then be merged to provide a 30 to 34 cm axial view.

[0025] Prior to reconstruction, the image projection data may be preprocessed to account for x-ray beam and detector properties and the system electronic and geometric properties. The algorithm and its implementation is similar to that used in single slice computer tomography in reconstruction of fan beam data obtained with a one-dimensional detector. For partial cone beam reconstruction, the partial cone image projection data is extended to full cone beam image data and then reconstructed using a full cone beam reconstruction algorithm well known to those of ordinary skill in the art, such as, for example, the Feldkamp cone beam reconstruction technique. It should be understood that the extension of the partial cone beam image data is performed using techniques similar to those used for the extension of partial fan data in well known single slice fan beam computer tomography.

[0026] Using the shape and distance data determined from the generated dimensional representation, the target volume may be automatically identified by the computer system 221 and/or by the inspection of an oncologist. The identified target volume may be applied to a radiotherapy planning computer system 220, which creates a treatment plan to be implemented by a clinical treatment machine. The visualization of the data along arbitrary planes, e.g. sagittal, coronal, axial, beams eye view, etc., can be displayed to assist the oncologist. To further enhance the visualization, averaging of volume image data perpendicular to the plane of view, i.e. rectangular voxels may be used.

[0027] Figure 3 is a side view of one embodiment of a clinical treatment machine 400 that may implement the treatment plan generated by the simulator 100 and treat-

ment planning computer 220. The clinical treatment machine 400 includes a rotatable gantry 402 pivotably attached to a drive stand 403. A cone-beam CT radiation source 404 and a flat panel imager oppose each other and are coupled to the rotatable gantry 402. The cone-beam CT radiation source 404 is a megavoltage (MV) radiation source generally in the 4 to 25 MV energy range, for example, at 6MV.

[0028] A treatment couch 418 is positioned adjacent to the gantry 402 to place the patient and the target volume within the range of operation for the radiation source 404 and the imager 406. The couch 418 can be capable of translating in multiple planes plus angulation for positioning and re-positioning the patient 405 and therefore the target volume.

[0029] The gantry 402 can rotate 414 about an isocenterline 415 to place the cone-beam CT radiation source 404 and imager 406 at any position 360 degrees around the target volume. The resulting megavoltage cone-beam CT image data can then be used to tailor a dose of therapeutic radiation based on at least the generated predefined treatment plan.

[0030] Figure 4 is a process diagram of one embodiment of a method for implementing a treatment plan. At block 510, an accelerator control computer 450 is provided with the treatment plan generated from the clinical simulator machine 100 for a specific patient. For example, the treatment plan may provide initial targeting information about the target volume. At block 520, a patient is placed on the treatment couch 418 and the couch 418 is positioned relative to the clinical treatment machine 400. At block 522, multi-mode cone beam radiation from the radiation source 404 is captured by the imager 406 to generate images of the target volume. The captured image data is compared/registered with the simulator or other reference images to determine the patient repositioning required, if any, before treatment. Image data can also be taken without repositioning to determine the random and systematic errors in treatment position, if any. At block 530, the gantry 402 is rotated around the patient 405 to a treatment position based on the generated treatment plan. At block 540, a therapeutic radiation dose is applied to the target volume from the cone-beam CT radiation source 404 based on the generated treatment plan. The cone-beam CT radiation source 404 also impinges the flat-panel imager 406 with radiation. In this way, the flat panel imager 406 may provide verification that the target volume is properly targeted. The process 500 may be repeated until the treatment session is complete.

[0031] The flat panel imager 406 is similar to the flat panel imager 206 including the corresponding interconnects with a command processor module 425, a computer 420, and a cone-beam reconstruction computer 421, corresponding with the command processor module 225, the computer 220, and the cone-beam reconstruction computer 221, as described above. However, the flat panel imager 406 may have its electronics unfolded from

beneath the imager 406 and the input screen coating may be thicker (e.g., 9 mm vs. 0.6 mm). An example of a flat panel imager that may be used in the present invention is described in US 6,800,858.

[0032] The imager 406 may also interface with an accelerator interface control box 451. The accelerator interface control box 451 interfaces with an accelerator control computer 450 to provide synchronization and gated control between the imager 406 and the cone-beam CT radiation source 404 during treatment based on the generated treatment plan. This allows single or multiple beam pulse images that are not affected by accelerator noise during readout.

[0033] The accelerator interface control box 451 may include a timing interface. The timing interface coordinates acquisition by the flat panel imager 406 and pulsing of the cone-beam CT radiation source 404. With this interface, as little as one radiation pulse (0.028 cGy at the isocenter) can be used to form projection images.

[0034] The timing interface may include a National Instruments PCI 6602 data acquisition card from National Instruments Corporation of Austin, Texas USA, that contains hardware and firmware for counting and timing pulses; computer software that provides control logic; and a user interface for the interface system. Alternatively, other cards may also be used.

[0035] A master clock signal is derived from a sync signal of the cone-beam CT radiation source 404, which may operate at 360 pulses/s (6 MV) or 180 pulses/s (15-18 MV), according to one example. Using a counter on the National Instruments PCI 6602 card, the sync signal is divided down to produce a master clock, and hence are timed relative to the production of cone-beam CT radiation pulses from the cone-beam CT radiation source 404.

[0036] The master clock may be used to generate two control pulses, one that gates the cone-beam CT radiation source 404 on and off and the other that triggers the flat panel imager 406. In one embodiment, the frequency of these pulses is user selectable, and may be any value below 30 pulses/sec. The relative timing of the two pulses may also be user selectable. When the flat panel imager 406 is triggered there is a period, while the image is being read out (half a frame time) during which no beam from the cone-beam CT radiation source 404 is desired. A user can enter the appropriate delay that will prevent irradiation during the frame readout period of the imager. The length of the gate pulse of the cone-beam CT radiation source 404 is also user selectable. By adjusting the width of the gate pulse, the user can control the number of beam pulses emitted by the cone-beam CT radiation source 404 during each gate pulse.

[0037] It should be appreciated that the MV cone-beam CT flat panel imager 406 has a high quantum efficient 9 mm thick CsI:TI screen (e.g., approximately 10% efficient at 6 MV), which preserves spatial resolution and minimizes dose to the patient by at least a factor of 5 over a standard 1 mm copper plate and thin less than 1 mm

GOS (gadolinium oxysulfide) screens used in standard flat panel and screen-camera portal imaging. Therefore, images with as low as one 6 MV accelerator beam pulse (e.g., 0.028 cGy) per frame may be collected. In addition, a low patient dose of 8 to 16 cGy per cone-beam CT data set may be yielded for 300 to 600 CT image frames or projections per data set. The lower dose of the MV cone-beam CT radiation allows for more frequent use on each patient during the typical 30 to 37 fractionated treatment sessions. Moreover, reduced spatial resolution on the MV cone-beam CT scans can be afforded for faster processing time using the cone-beam reconstruction software on the CBR computer 421 to achieve rapid image generation.

[0038] It should be appreciated that a separate kV cone-beam CT radiation source (not shown) and another opposing flat panel imager (as described above on the simulator but not shown here) may also be coupled to the gantry 404 to perform a diagnostic cone-beam CT scan. For example, the kV cone-beam CT radiation source and opposing flat panel imager may be coupled to the treatment machine gantry 404 at an off axis of e.g. forty-five or ninety degrees from the MV cone-beam radiation source 404 and opposing imager 406. As before, software in the computers 420 and/or 421 may generate the three-dimensional representation of the patient anatomy and target volume from the cone-beam CT image data provided by the kV radiation source. The clinical treatment machine 400 may use the kV cone-beam CT image data to make any necessary adjustments to the treatment plan based on identified movement of the target volume or to determine the amount of patient repositioning required by the treatment couch 418 or collimator movements. In this way, the kV cone-beam CT radiation source and flat panel imager share a common axis of rotation with the MV cone-beam CT radiation source 404 and provide additional information for aligning the patient to the generated simulation treatment plan.

[0039] It should also be appreciated that in this way, either the clinical simulator machine 100 and/or the clinical treatment machine 400 diagnostic cone-beam CT image data can be used as a reference for applying the MV radiation beams.

[0040] It should also be understood that it is not necessary for the therapeutic radiation to be applied from the exact position(s) where any of the previously generated CT images were taken since the computer software can provide virtual two-dimensional representations for any desired radial location in-between the images.

[0041] It should be understood that although the clinical treatment machine 400 has been described as having a cone-beam radiation source, in alternative examples beam shaping, along with intensity modulation, may also be implemented based on the generated treatment plan by directing a therapeutic beam through a dynamic multileaf collimator. The multileaf collimator may include a series of stacked metal shims having a center of shim pairs where each shim of the pairs may be individually

moved to create a shaped opening capable of shaping the therapeutic beam. To be effective, the radiation field should be large enough to radiate the entire tumor while at the same time minimize radiating healthy tissue. The collimator may be dynamic in that the shims can rapidly move to reshape the beam, which results in blocking the therapeutic beam from striking certain areas of the target volume based on the treatment plan. Such dynamic shaping may result in different areas of the tumor receiving different amounts of radiation over the time that a radiation dose is applied.

[0042] It should be appreciated that more or fewer processes may be incorporated into the methods illustrated in Figures 2 and 4 without departing from the scope of the invention and that no particular order is implied by the arrangement of blocks shown and described herein. It further will be appreciated that the method described in conjunction with Figures 2 and 4 may be embodied in machine-executable instructions (e.g. software). The instructions can be used to cause a general-purpose or special-purpose processor that is programmed with the instructions to perform the operations described. Alternatively, the operations might be performed by specific hardware components that contain hardwired logic for performing the operations, or by any combination of programmed computer components and custom hardware components. The methods may be provided as a computer program product that may include a machine-readable medium having stored thereon instructions that may be used to program a computer (or other electronic devices) to perform the methods. For the purposes of this specification, the terms "machine-readable medium" shall be taken to include any medium that is capable of storing or encoding a sequence of instructions for execution by the machine and that cause the machine to perform any one of the methodologies of the present invention. The term "machine-readable medium" shall accordingly be taken to include, but not be limited to, solid-state memories, optical and magnetic disks, and carrier wave signals. Furthermore, it is common in the art to speak of software, in one form or another (e.g., program, procedure, process, application, module, logic...), as taking an action or causing a result. Such expressions are merely a shorthand way of saying that execution of the software by a computer causes the processor of the computer to perform an action or produce a result.

[0043] It should be appreciated that a clinical simulation machine having a cone-beam radiation source and flat-panel imagers, as described, allows for identification of a target volume via fluoroscopic, radiographic, and cone-beam CT imaging. In this way, the generation of the treatment plan via the clinical simulation machine prior to the application of therapeutic radiation, increases the accuracy of treating the tumor target. Furthermore, embodiments of the invention as described above may capture images while the gantry is continuously rotating versus traditional systems that stop and shoot every, approximately, four degrees around the patient, thereby fur-

ther lessening the time for completion.

[0044] It should also be appreciated that the cone-beam volumetric reconstruction software can utilize image projection data at non-uniformly spaced gantry angles. Thus the data collection does not require a precise gantry speed of rotation. There is a normalizing detector at the radiation source, which is used to correct for system output variations. The support arms for the images 206 and 406 may be sufficiently precise in mechanical stability during gantry rotation that no compensating spatial corrections are required.

[0045] Although the present invention has been described with reference to specific exemplary embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the scope of the invention as set forth in the claims. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

Claims

1. An apparatus (400), comprising:

a rotatable gantry (402);
a translatable treatment couch (418) coupled to the rotatable gantry via a communications network (440); a control computer (450) for receiving a treatment plan to instruct the apparatus to at least adjust a therapeutic megavoltage radiation source into position to align a treatment volume with the therapeutic megavoltage radiation source;
first means (404) for applying a first cone-beam radiation beam coupled to the rotatable gantry, wherein the first means for applying includes a kilovoltage radiation source;
second means (404) for applying a second cone-beam radiation beam coupled to the rotatable gantry using the treatment plan, wherein the second means for applying includes the therapeutic megavoltage radiation source;
first means (406) for capturing first image projection data applied by the kilovoltage radiation source with a first flat-panel kilovoltage radiation imager, which is coupled to the rotatable gantry;
second means (406) for capturing second image projection data applied by the megavoltage radiation source with a different, second flat-panel megavoltage radiation imager, which is coupled to the rotatable gantry;
means (420) for storing the captured image projection data coupled to the rotatable gantry via a communications network (440);
means (421) for generating cone-beam computed tomography (CT) volumetric image data from the captured image projection data captured by

- the first flat-panel imager; **characterised in that** said control computer (450) is configured for determining the patient repositioning required to begin a treatment based on a comparison of the second image projection data with at least one reference image
2. The apparatus of claim 1, wherein said control computer is configured for determining the patient repositioning required to continue the treatment based on a comparison of the captured image projection data applied by the first or second means for applying with at least one reference image
 3. The apparatus of claim 1, wherein the second means for capturing image projection data is adapted for capturing image projection data at non-uniformly spaced angles.
 4. The apparatus of claim 1, wherein the second means for capturing image projection data is adapted for capturing image projection data at non-uniformly spaced angles.
 5. The apparatus of claim 1, wherein said control computer is configured for using the cone-beam computed tomography (CT) volumetric image data to modify the treatment plan.
 6. The apparatus of claim 1, wherein the first means for capturing includes an amorphous silicon sensor array.
 7. The apparatus of claim 6, wherein the first means for capturing includes a high-sensitivity cesium iodide scintillator for kilovoltage imaging.
 8. The apparatus of claim 7, wherein the scintillator includes thick cesium iodide crystals coated with a reflective powder and epoxy mixture in a large matrix for megavoltage imaging.
 9. The apparatus of any preceding claim, wherein the first means for capturing is capable of high frame rate fluoroscopic imaging.
 10. The apparatus of any preceding claim, wherein the first means for capturing is adapted to capture the image data at 15 to 30 frames per seconds.
 11. The apparatus of any preceding claim, wherein the translatable treatment couch is capable of movement in three planes plus angulation.
 12. The apparatus of any preceding claim, wherein the rotatable gantry is capable of 360-degree rotation.
 13. The apparatus of any preceding claim, wherein the control computer is configured for continuously rotating the gantry about the target volume while capturing images.
 14. The apparatus of claim 1, wherein the first captured image projection data is generated from the kilovoltage flat-panel imager capturing radiation from a cone-beam radiation source passing through the target volume.
 15. The apparatus of claim 14, wherein the first means for capturing is arranged to capture the image projection data at a frame rate in the range of 15-30 frames per second.
 16. The apparatus of any of claims 14 or 15, wherein the first image projection data is fluoroscopic image projection data.
 17. A machine-readable storage medium comprising instructions to cause a clinical treatment machine (400) to perform a method to perform a clinical treatment, the method comprising:

receiving a treatment plan to instruct the apparatus to at least adjust a therapeutic megavoltage radiation source into position to align a treatment volume with the therapeutic megavoltage radiation source, the megavoltage radiation source being coupled to a rotatable gantry (402); instructing the clinical treatment machine (400) to capture first image projection data from a first flat-panel kilovoltage imager (406) coupled to the rotatable gantry (402), the first image projection data being for generating cone-beam computed tomography (CT) volumetric image data, wherein the first image projection data is from a cone-beam kilovoltage radiation beam source coupled to the rotatable gantry (402); instructing the clinical treatment machine (400) to apply a megavoltage cone-beam radiation beam from the therapeutic megavoltage radiation source using the treatment plan; instructing the clinical treatment machine (400) to capture second image projection data from a second flat-panel megavoltage imager (406) coupled to the rotatable gantry (402), storing the first and second captured image projection data; and determining the patient repositioning required to begin a treatment based on a comparison of the second image projection data with a least one reference image wherein a translatable treatment couch is coupled to the rotatable gantry via a communications network (440).
 18. The machine-readable medium of claim 17, the method further comprising: transferring the treat-

ment plan from a simulator machine (100) to the clinical treatment machine, wherein the clinical treatment machine implements the treatment plan.

19. The machine-readable medium of claim 17 or 18, the method further comprising continuously rotating the gantry about the target volume while capturing images. 5
20. A computer program product for controlling a translatable treatment couch (418) and placing a patient, on the couch, in an operative position to begin a treatment using the apparatus (400) of any of claims 1 to 16, the computer program being adapted to: 10

control the means for capturing image projection data in order to capture first image projection data from a first flat-panel kilovoltage imager (406) and to capture second image projection data from a second flat-panel megavoltage imager (406), both of which imagers (406) are coupled to the rotatable gantry (402), the first image projection data being for generating cone-beam computed tomography (CT) volumetric image data, wherein the first image projection data is from a cone-beam kilovoltage radiation beam source coupled to the rotatable gantry, and wherein the second image projection data is from a cone-beam megavoltage radiation beam source coupled to the rotatable gantry; 20

store the captured first and second image projection data; and determine the patient repositioning required to begin a treatment based on a comparison of the second image projection data with a least one reference image wherein a translatable treatment couch is coupled to the rotatable gantry via a communications network (440). 25

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Patentansprüche

1. Vorrichtung (400), umfassend:

ein drehbares Portal (402); 45

eine verschiebbare Behandlungsliege (418), die über ein Kommunikationsnetzwerk (440) an das drehbare Portal gekoppelt ist;

einen Steuercomputer (450) zum Empfangen eines Behandlungsplans, um die Vorrichtung anzuweisen, wenigstens eine therapeutische Megavolt-Strahlungsquelle in Position zu bringen, um ein Behandlungsvolumen mit der therapeutischen Megavolt-Strahlungsquelle auszurichten; 50

erstes Mittel (404) zum Anwenden eines ersten Kegelstrahl-Strahlungsstrahls, der an das drehbare Portal gekoppelt ist, wobei das erste Mittel 55

zum Anwenden eine Kilovolt-Strahlungsquelle einschließt;

zweites Mittel (404) zum Anwenden eines zweiten Kegelstrahl-Strahlungsstrahls, der unter Verwendung des Behandlungsplans an das drehbare Portal gekoppelt ist, wobei das zweite Mittel zum Anwenden die therapeutische Megavolt-Strahlungsquelle einschließt;

erstes Mittel (406) zum Erfassen von ersten Bildprojektionsdaten, die von der Kilovolt-Strahlungsquelle mit einem ersten Flachbildschirm-Kilovolt-Strahlungsbildgeber angelegt werden, der an das drehbare Portal gekoppelt ist;

zweites Mittel (406) zum Erfassen von zweiten Bildprojektionsdaten, die von der Megavolt-Strahlungsquelle mit einem anderen, zweiten Flachbildschirm-Megavolt-Strahlungsbildgeber angelegt werden, der an das drehbare Portal gekoppelt ist;

Mittel (420) zum Speichern der erfassten Bildprojektionsdaten, die über ein Kommunikationsnetzwerk (440) an das drehbare Portal gekoppelt sind;

Mittel (421) zum Erzeugen von volumetrischen Bilddaten der Kegelstrahl-Computertomographie (CT) aus den erfassten Bildprojektionsdaten, die von dem ersten Flachbildschirm-Bildgeber erfasst werden; **dadurch gekennzeichnet, dass** der Steuercomputer (450) zum Bestimmen der Patientenrepositionierung konfiguriert ist, die erforderlich ist, um eine Behandlung auf der Grundlage eines Vergleichs der zweiten Bildprojektionsdaten mit mindestens einem Referenzbild zu beginnen. 40

2. Vorrichtung nach Anspruch 1, wobei der Steuercomputer zum Bestimmen der Patientenrepositionierung konfiguriert ist, die erforderlich ist, um die Behandlung auf der Grundlage eines Vergleichs der erfassten Bildprojektionsdaten, die durch das erste oder zweite Mittel zum Anwenden angewendet werden, mit mindestens einem Referenzbild fortzusetzen. 45

3. Vorrichtung nach Anspruch 1, wobei das zweite Mittel zum Erfassen von Bildprojektionsdaten für die Erfassung von Bildprojektionsdaten in uneinheitlich beabstandeten Winkeln ausgelegt ist. 50

4. Vorrichtung nach Anspruch 1, wobei das zweite Mittel zum Erfassen von Bildprojektionsdaten für die Erfassung von Bildprojektionsdaten in uneinheitlich beabstandeten Winkeln ausgelegt ist. 55

5. Vorrichtung nach Anspruch 1, wobei der Steuerrechner konfiguriert ist, um die volumetrischen Bilddaten der Kegelstrahl-Computertomographie (CT) zu verwenden, um den Behandlungsplan zu modifizieren.

6. Vorrichtung nach Anspruch 1, wobei das erste Mittel zum Erfassen eine Sensoranordnung aus amorphem Silizium einschließt.
7. Vorrichtung nach Anspruch 6, wobei das erste Mittel zum Erfassen einen hochempfindlichen Cäsiumjodid-Szintillator für die Kilovolt-Bildgebung einschließt. 5
8. Vorrichtung nach Anspruch 7, wobei der Szintillator dicke Cäsiumjodidkristalle einschließt, die mit einem reflektierenden Pulver und einer Epoxidmischung in einer großen Matrix für Megavolt-Bildgebung beschichtet sind. 10
9. Vorrichtung nach einem vorstehenden Anspruch, wobei das erste Mittel zum Erfassen zu einer fluoroskopischen Bildgebung mit hoher Bildwechselfrequenz in der Lage ist. 15
10. Vorrichtung nach einem vorstehenden Anspruch, wobei das erste Mittel zum Erfassen ausgelegt ist, die Bilddaten mit 15 bis 30 Bildwechseln pro Sekunde zu erfassen. 20
11. Vorrichtung nach einem vorstehenden Anspruch, wobei die verschiebbare Behandlungsliege zu einer Bewegung in drei Ebenen plus Winkelung in der Lage ist. 25
12. Vorrichtung nach einem vorstehenden Anspruch, wobei das drehbare Portal zu einer 360-Grad-Drehung in der Lage ist. 30
13. Vorrichtung nach einem vorstehenden Anspruch, wobei der Steuercomputer konfiguriert ist, um das Portal kontinuierlich während der Bilderfassung um das Zielvolumen zu drehen. 35
14. Vorrichtung nach Anspruch 1, wobei die ersten erfassten Bildprojektionsdaten von dem Flachbildschirm-Kilovolt-Strahlungsbildgeber erzeugt werden, der Strahlung aus einer Kegelstrahl-Strahlungsquelle erfasst, die durch das Zielvolumen hindurchtritt. 40
15. Vorrichtung nach Anspruch 14, wobei das erste Mittel zum Erfassen angeordnet ist, um die Bildprojektionsdaten mit einer Bildwechselfrequenz im Bereich von 15-30 Bildwechseln pro Sekunde zu erfassen. 50
16. Vorrichtung nach einem der Ansprüche 14 oder 15, wobei die ersten Bildprojektionsdaten fluoroskopische Bildprojektionsdaten sind. 55
17. Maschinenlesbares Speichermedium, das Anweisungen umfasst, um eine klinische Behandlungsmaschine (400) dazu zu veranlassen, ein Verfahren zur

Durchführung einer klinischen Behandlung durchzuführen, wobei das Verfahren Folgendes umfasst:

Empfangen eines Behandlungsplans, um die Vorrichtung anzuweisen, wenigstens eine therapeutische Megavolt-Strahlungsquelle in Position zu bringen, um ein Behandlungsvolumen mit der therapeutischen Megavolt-Strahlungsquelle auszurichten, wobei die Megavolt-Strahlungsquelle an ein drehbares Portal (402) gekoppelt ist;

Anweisen der klinischen Behandlungsmaschine (400), erste Bildprojektionsdaten von einem ersten Flachbildschirm-Kilovolt-Bildgeber (406) zu erfassen, der an das drehbare Portal (402) gekoppelt ist, wobei die ersten Bildprojektionsdaten zum Erzeugen von volumetrischen Bilddaten der Kegelstrahl-Computertomographie (CT) dienen, wobei die ersten Bildprojektionsdaten von einer Kegelstrahl-Kilovolt-Strahlungsstrahlungsquelle stammen, die an das drehbare Portal (402) gekoppelt ist;

Anweisen der klinischen Behandlungsmaschine (400), unter Verwendung des Behandlungsplans einen Megavolt-Kegelstrahl-Strahlungsstrahl aus der therapeutischen Megavolt-Strahlungsquelle anzulegen;

Anweisen der klinischen Behandlungsmaschine (400), zweite Bildprojektionsdaten von einem zweiten Flachbildschirm-Megavolt-Bildgeber (406) zu erfassen, der an das drehbare Portal (402) gekoppelt ist,

Speichern der ersten und zweiten erfassten Bildprojektionsdaten; und

Bestimmen der Patientenrepositionierung, die erforderlich ist, um eine Behandlung auf der Grundlage eines Vergleichs der zweiten Bildprojektionsdaten mit mindestens einem Referenzbild zu beginnen, wobei eine verschiebbare Behandlungsliege über ein Kommunikationsnetzwerk (440) an das drehbare Portal gekoppelt ist.

18. Maschinenlesbares Medium nach Anspruch 17, wobei das Verfahren weiter Folgendes umfasst:

Übertragen des Behandlungsplans von einer Simulatormaschine (100) auf die klinische Behandlungsmaschine, wobei die klinische Behandlungsmaschine den Behandlungsplan umsetzt.

19. Maschinenlesbares Medium nach Anspruch 17 oder 18, wobei das Verfahren weiter kontinuierliches Drehen des Portals um das Zielvolumen während Bilder erfasst werden umfasst.

20. Computerprogrammprodukt zum Steuern einer ver-

schiebbaren Behandlungsliege (418) und zum Platzieren eines Patienten auf der Liege in einer Betriebsposition, um eine Behandlung unter Verwendung der Vorrichtung (400) nach einem der Ansprüche 1 bis 16 zu beginnen, wobei das Computerprogramm ausgelegt ist zum:

Steuern der Mittel zum Erfassen von Bildprojektionsdaten, um erste Bildprojektionsdaten von einem ersten Flachbildschirm-Kilovolt-Bildgeber (406) zu erfassen und zweite Bildprojektionsdaten von einem zweiten Flachbildschirm-Megavolt-Bildgeber (406) zu erfassen, wobei beide Bildgeber (406) an das drehbare Portal (402) gekoppelt sind, wobei die ersten Bildprojektionsdaten zum Erzeugen von volumetrischen Bilddaten der Kegelstrahl-Computertomographie (CT) dienen, wobei die ersten Bildprojektionsdaten von einer Kegelstrahl-Kilovolt-Strahlungsquelle stammen, die an das drehbare Portal gekoppelt ist, und wobei die zweiten Bildprojektionsdaten von einer Kegelstrahl-Megavolt-Strahlungsquelle stammen, die an das drehbare Portal gekoppelt ist;

Speichern der erfassten ersten und zweiten Bildprojektionsdaten; und

Bestimmen der Patientenrepositionierung, die erforderlich ist, um eine Behandlung auf der Grundlage eines Vergleichs der zweiten Bildprojektionsdaten mit mindestens einem Referenzbild zu beginnen, wobei eine verschiebbare Behandlungsliege über ein Kommunikationsnetzwerk (440) an das drehbare Portal gekoppelt ist.

Revendications

1. Appareil (400), comprenant :

un portique rotatif (402) ;

un divan de traitement capable d'être entraîné en translation (418) couplé au portique rotatif par l'intermédiaire d'un réseau de communications (440) ;

un ordinateur de commande (450) pour recevoir un plan de traitement pour instruire l'appareil d'ajuster au moins une source de rayonnement thérapeutique de l'ordre du mégavolt en position afin d'aligner un volume de traitement avec la source de rayonnement thérapeutique de l'ordre du mégavolt ;

un premier moyen (404) d'application d'un premier faisceau de rayonnement à faisceau conique couplé au portique rotatif, dans lequel le premier moyen d'application comprend une source de rayonnement de l'ordre du kilovolt ;

un second moyen (404) d'application d'un se-

cond faisceau de rayonnement à faisceau conique couplé au portique rotatif à l'aide du plan de traitement, dans lequel le second moyen d'application comprend la source de rayonnement thérapeutique de l'ordre du mégavolt ;

un premier moyen (406) de capture de premières données de projection d'image appliquées par la source de rayonnement de l'ordre du kilovolt avec un premier imageur de rayonnement à écran plat de l'ordre du kilovolt, qui est couplé au portique rotatif ;

un second moyen (406) de capture de secondes données de projection d'image appliquées par la source de rayonnement de l'ordre du mégavolt avec un second imageur de rayonnement à écran plat de l'ordre du mégavolt, différent, qui est couplé au portique rotatif ;

un moyen (420) de stockage des données de projection d'image capturées couplé au portique rotatif par l'intermédiaire d'un réseau de communications (440) ;

un moyen (421) de génération de données d'image volumétriques de tomodensitométrie (CT) à faisceau conique à partir des données de projection d'image capturées, capturées par le premier imageur à écran plat; **caractérisé en ce que** ledit ordinateur de commande (450) est configuré pour déterminer le repositionnement du patient requis pour commencer un traitement sur la base d'une comparaison des secondes données de projection d'image à au moins une image de référence.

2. Appareil selon la revendication 1, dans lequel ledit ordinateur de commande est configuré pour déterminer le repositionnement du patient requis pour poursuivre le traitement sur la base d'une comparaison des données de projection d'image capturées appliquées par les premier ou second moyens d'application, à au moins une image de référence.

3. Appareil selon la revendication 1, dans lequel le second moyen de capture de données de projection d'image est approprié pour capturer des données de projection d'image à des angles non uniformément espacés.

4. Appareil selon la revendication 1, dans lequel le second moyen de capture de données de projection d'image est approprié pour capturer des données de projection d'image à des angles non uniformément espacés.

5. Appareil selon la revendication 1, dans lequel ledit ordinateur de commande est configuré pour utiliser les données d'image volumétriques de tomodensitométrie (CT) à faisceau conique pour modifier le plan de traitement.

6. Appareil selon la revendication 1, dans lequel le premier moyen de capture comprend un réseau de capteurs au silicium amorphe.
7. Appareil selon la revendication 6, dans lequel le premier moyen de capture comprend un scintillateur d'iodure de césium à haute sensibilité pour une imagerie de l'ordre du kilovolt.
8. Appareil selon la revendication 7, dans lequel le scintillateur comprend des cristaux épais d'iodure de césium revêtus d'une poudre réfléchissante et d'un mélange époxyde dans une grande matrice pour une imagerie de l'ordre du mégavolt.
9. Appareil selon l'une quelconque des revendications précédentes, dans lequel le premier moyen de capture est capable d'effectuer une imagerie fluoroscopique à haute fréquence de trames.
10. Appareil selon l'une quelconque des revendications précédentes, dans lequel le premier moyen de capture est approprié pour capturer les données d'image à 15 à 30 trames par seconde.
11. Appareil selon l'une quelconque des revendications précédentes, dans lequel le divan de traitement capable d'être entraîné en translation est capable d'être déplacé dans trois plans et en inclinaison.
12. Appareil selon l'une quelconque des revendications précédentes, dans lequel le portique rotatif est capable d'effectuer une rotation de 360 degrés.
13. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'ordinateur de commande est configuré pour entraîner en rotation continue le portique autour du volume cible pendant la capture d'images.
14. Appareil selon la revendication 1, dans lequel les premières données de projection d'image capturées sont générées à partir de l'imageur à écran plat de l'ordre du kilovolt capturant un rayonnement provenant d'une source de rayonnement à faisceau conique traversant le volume cible.
15. Appareil selon la revendication 14, dans lequel le premier moyen de capture est agencé pour capturer les données de projection d'image à une fréquence de trames dans la plage de 15 à 30 trames par seconde.
16. Appareil selon l'une quelconque des revendications 14 ou 15, dans lequel les premières données de projection d'image sont des données de projection d'image fluoroscopique.
17. Support de stockage lisible par machine, comprenant des instructions pour amener une machine de traitement clinique (400) à exécuter un procédé pour exécuter un traitement clinique, le procédé comprenant :
- la réception d'un plan de traitement pour instruire l'appareil d'ajuster au moins une source de rayonnement thérapeutique de l'ordre du mégavolt en position afin d'aligner un volume de traitement avec la source de rayonnement thérapeutique de l'ordre du mégavolt, la source de rayonnement de l'ordre du mégavolt étant couplée à un portique rotatif (402) ;
- l'instruction de la machine de traitement clinique (400) de capturer de premières données de projection d'image à partir d'un premier imageur à écran plat de l'ordre du kilovolt (406) couplé au portique rotatif (402), les premières données de projection d'image étant destinées à générer des données d'image volumétriques de tomodensitométrie (CT) à faisceau conique, dans lequel les premières données de projection d'image proviennent d'une source de faisceau de rayonnement de l'ordre du kilovolt à faisceau conique couplée au portique rotatif (402) ;
- l'instruction de la machine de traitement clinique (400) d'appliquer un faisceau de rayonnement de l'ordre du mégavolt à faisceau conique à partir de la source de rayonnement thérapeutique de l'ordre du mégavolt à l'aide du plan de traitement ;
- l'instruction de la machine de traitement clinique (400) de capturer de secondes données de projection d'image à partir d'un imageur à écran plat de l'ordre du mégavolt (406) couplé au portique rotatif (402),
- le stockage des premières et secondes données de projection d'image capturées ; et
- la détermination du repositionnement du patient requis pour commencer un traitement sur la base d'une comparaison des secondes données de projection d'image à au moins une image de référence, dans lequel un divan de traitement capable d'être entraîné en translation est couplé au portique rotatif par l'intermédiaire d'un réseau de communications (440).
18. Support lisible par machine selon la revendication 17, le procédé comprenant en outre :
- le transfert du plan de traitement à partir d'une machine de simulation (100) à la machine de traitement clinique, dans lequel la machine de traitement clinique met en oeuvre le plan de traitement.
19. Support lisible par machine selon la revendication

17 ou 18, le procédé comprenant en outre la rotation continue du portique autour du volume cible pendant la capture d'images.

20. Produit de programme informatique pour commander un divan de traitement (418) capable d'être entraîné en translation et positionner un patient, sur le divan, dans une position opérationnelle pour commencer un traitement à l'aide de l'appareil (400) selon l'une quelconque des revendications 1 à 16, le programme informatique étant approprié pour :

commander le moyen de capture de données de projection d'image afin de capturer de premières données de projection d'image à partir d'un premier imageur à écran plat de l'ordre du kilovolt (406) et de capturer de secondes données de projection d'image à partir d'un second imageur à écran plat de l'ordre du mégavolt (406), les deux imageurs (406) sont couplés au portique rotatif (402), les premières données de projection d'image étant destinées à générer des données d'image volumétriques de tomodensitométrie (CT) à faisceau conique, dans lequel les premières données de projection d'image proviennent d'une source de faisceau de rayonnement de l'ordre du kilovolt à faisceau conique couplée au portique rotatif, et dans lequel les secondes données de projection d'image proviennent d'une source de faisceau de rayonnement de l'ordre du mégavolt à faisceau conique couplée au portique rotatif ; stocker les premières et secondes données de projection d'image capturées ; et déterminer le repositionnement du patient requis pour commencer un traitement sur la base d'une comparaison des secondes données de projection d'image à au moins une image de référence, dans lequel un divan de traitement capable d'être entraîné en translation est couplé au portique rotatif par l'intermédiaire d'un réseau de communications (440).

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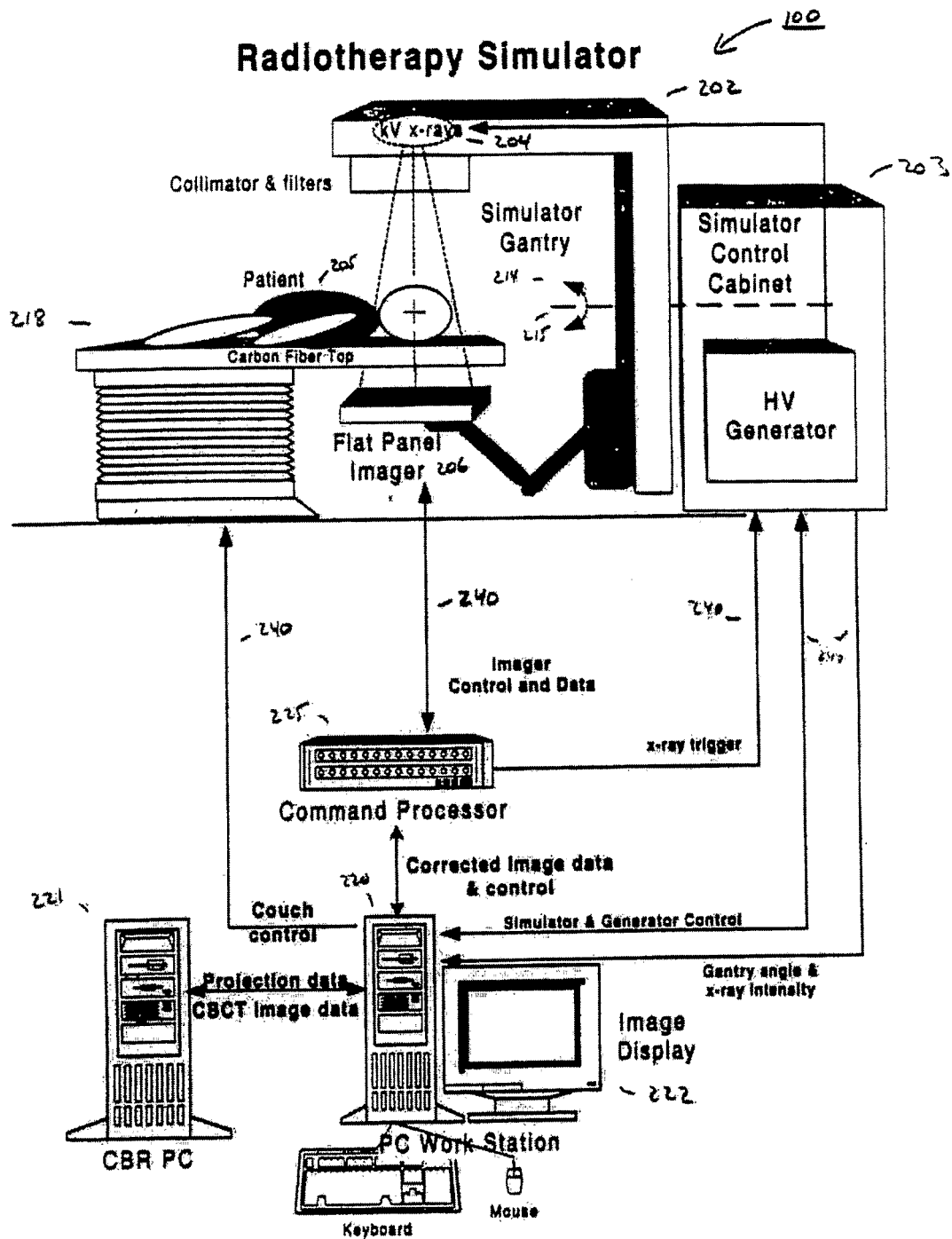


Figure 1- Simulator kV Cone Beam CT Diagram

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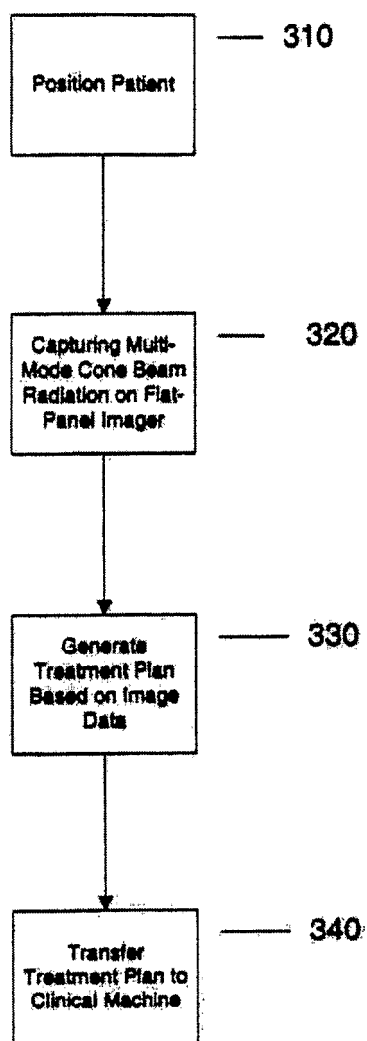


Figure 2

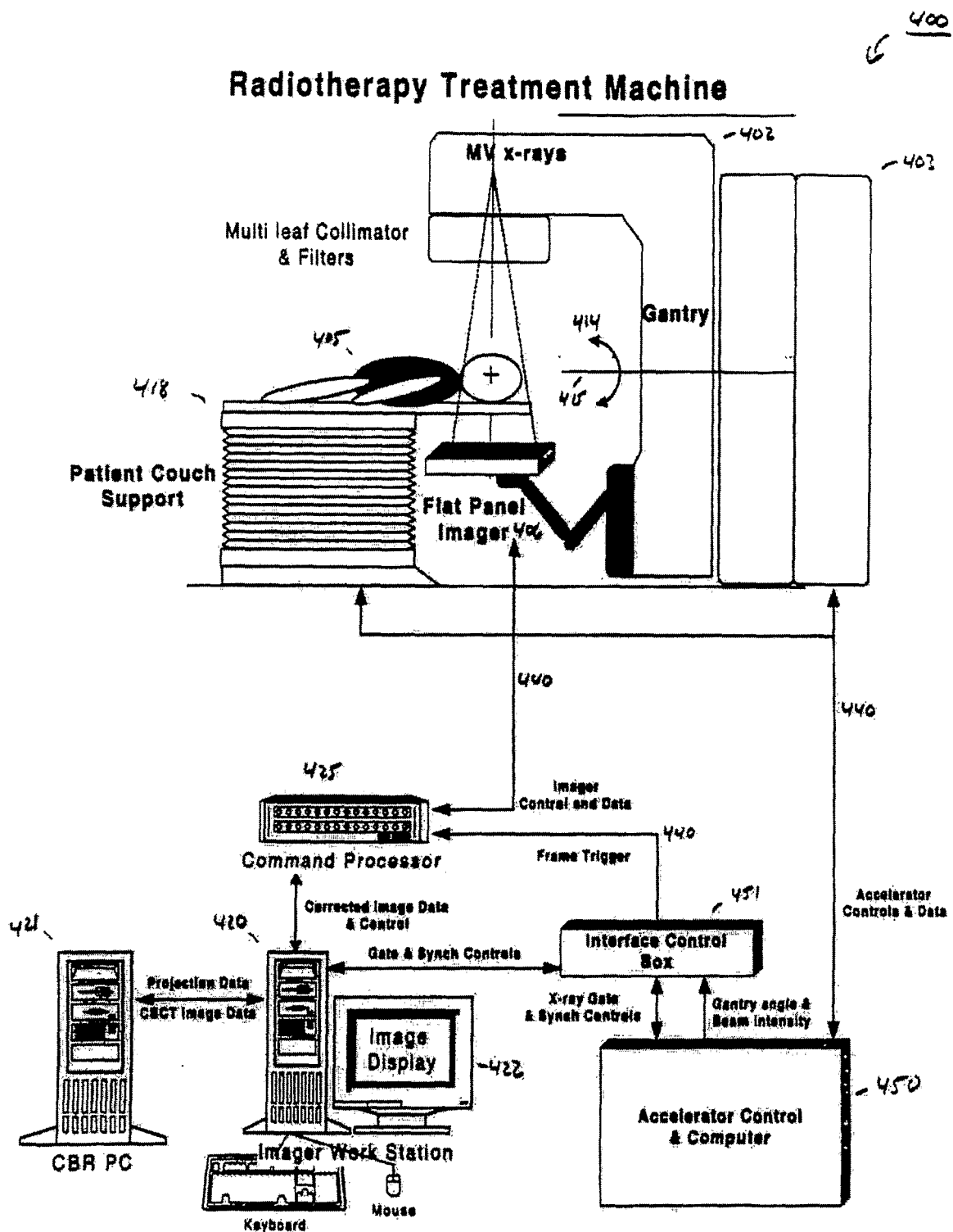
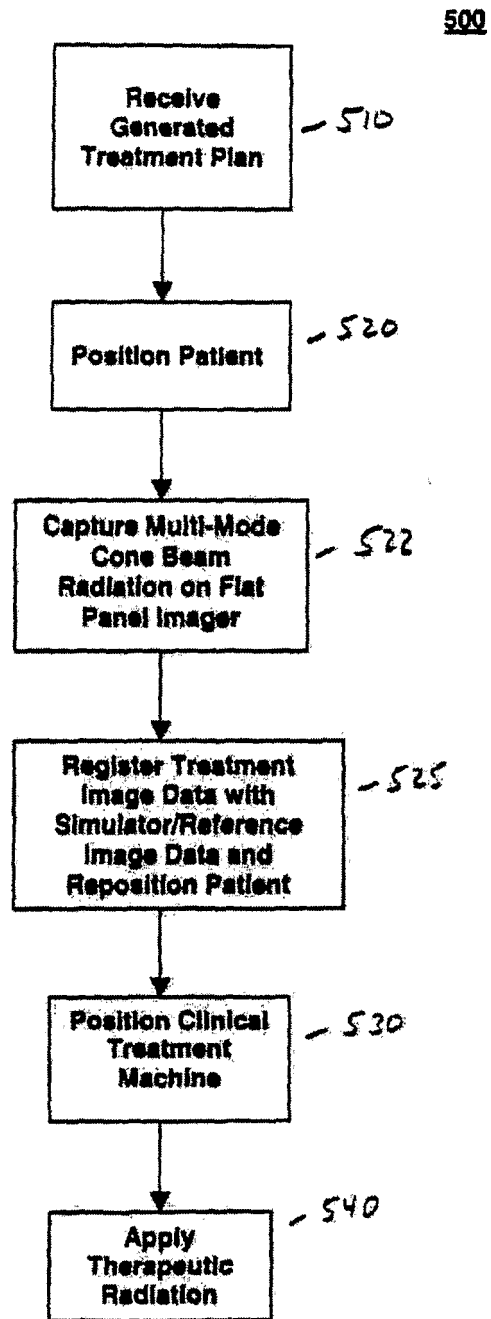


Figure 3- MV Cone Beam CT Diagram

Figure 4



REFERENCES CITED IN THE DESCRIPTION

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